Biology Department
Unit-Level Assessment Liaison Report
Spring 2020

Liaison Project Date: Fall 2019

Liaison Report prepared by Yevgeniya Lapik

This project constituted the final stages of the significant undertaking that Biology UL Assessment Liaison Aigerim Bijelic started in Spring 2018.

Dr. Bijelic successfully completed the first four stages of the project and most of the fifth stage [1].

I. Department Buy-In and Outcome Definition
II. Assessment Research and Design
III. Pilot Assessment Tools and Processes
IV. Administer Specific Assessment
V. Data Analysis (partial)
VI. Supporting Evidence Based Change (partial)

To briefly summarize, a comprehensive 20 multiple-choice questions assessment tool has been designed around core concepts and SLOs of the introductory biology for majors course Biology 121, administered as a pilot, edited by the Biology Department Assessment Committee, and administered as a pre-test in the beginning of the Fall 2018 semester and to all sections of the course offered at the department (260 students total). At the end of the Fall 2018 semester, the same tool was administered as a post-test to all but 1 section of the course (155 students total). The data analysis was focused on responses from 134 students that had a record, based on student ID, of taking both the pre-test and post-test assessments. A statistically significant improvement in student performance (at the standard 0.05 level) was detected (p-value = 4.27×10^{-5}): the average student performance in the post-test (Mean=61.58%) was statistically significantly higher than the average student performance in the pre-test (Mean=50.56%). The effect size, also known as "Learning Gain," which indicates the importance of the difference between the posttest and pretest scores, was calculated to be equal to 0.77, which is considered to be somewhat large [2] and, thus, the learning gain was substantial.

When I became a Biology Unit-Level Liaison in the Fall of 2018, I decided to dive into the data obtained in this project in more detail, and that was the focus of my work during that semester.

While, indisputably, individual students come into the course with different background levels of biological concept understanding, and, while taking the course, learn the concepts to a

different extent, in this analysis we are not looking at learning of individual students but of an overall student population that is taking the course: thus, for example, when I state that students have a good background mastery of a particular concept, it means that more than 70% of students answered the question addressing that particular concept in the pre-test correctly.

In general terms, we can record five main observations from the assessment data for this project:

Observation 1: Students began the course with different levels of understanding of key biological concepts ranging from very poor to good (based on pre-assessment)

Observation 2: Students left the course with a significant learning gain and with different levels of understanding of key biological concepts ranging from poor to good (based on post-assessment)

Observation 3: As students progressed through the course, their improvement in mastery of different concepts varied from nonexistent to significant (depending on the concept)

Observation 4: Students have misconceptions about certain biological concepts, which can prevent them from learning those concepts

Observation 5: Taking the course allowed students to clear some (but not all) of the biological misconceptions

In the remainder of the report I will provide data illustrating each of the five observations and then present the analysis of student answers to each question of the survey.

Observation 1: Students began the course with different levels of understanding of key biological concepts ranging from very poor to good (based on pre-assessment)

For the purposes of data analysis, I divided assessment tool questions into categories, based on the proportion of correct answers students provided to each in the pre-assessment (pre-test), see Figure 1:

Category 1 (Questions 5 and 18)- over 75 % students answered these questions correctly, so the student population, on the whole, demonstrated a **"good knowledge"** of the concepts targeted by these questions

Category 2 (Questions 1, 2, 4, 7, 11, 13, 16, 19 and 20) **-** majority of students (50 to 70%) answered these questions correctly, so the student population, on the whole, demonstrated a **"moderate knowledge"** of the concepts targeted by these questions

- **Category 3** (Questions 3, 6, 8, 9, 10 and 17) – only 30 to 50% of students could answer these questions correctly, so the student population, on the whole, demonstrated a **"poor knowledge"** of the concepts targeted by these questions

- **Category 4** (Questions 12, 14 and 15) - less than 30% of students answered these questions correctly, so the student population, on the whole, demonstrated a **"very poor knowledge"** of the concepts targeted by these questions

Question	PRE-TEST Correct answer (%) in declinining order	Groups
Q18	82.31%	Over 70% of students answered the questions correctly "good knowledge"
Q5	75.77%	
Q13	68.85%	Over 50 to 70% of students answered the questions correctly "moderate knowledge"
Q1	66.92%	
Q7	66.54%	
Q19	61.92%	
Q20	56.92%	
Q11	56.54%	
Q2	54.62%	
Q4	54.62%	
Q16	53.08%	
Q6	50.00%	30 to 50% of students answered the questions correctly "poor knowledge"
Q10	48.85%	
Q17	42.31%	
Q9	39.23%	
Q3	35.00%	
Q8	30.00%	
Q12	26.92%	Less than 30% of students answered the question correctly "very poor knowledge"
Q15	23.46%	
Q14	16.54%	

Figure 1. Student background knowledge of key biological concepts assessed in this project can be classified in four categories: "good knowledge," "moderate knowledge," "poor knowledge," and "very poor knowledge" (based on student answers to pre-assessment)

Several of the assessment survey questions targeted the same student learning outcomes (SLOs), so I attempted to match specific questions with underlining SLO to see if they fall within the same category of background knowledge (Figure 2).

Q18, Q17, Q12 all target SLO 14 (Compare and contrast the outcomes of cell division via mitosis and meiosis) and the corresponding background knowledge was spread among three different categories: "good knowledge," "poor knowledge" and "very poor knowledge"

Q5 and 6 target SLO 5 (Compare and contrast four classes of biological molecules: carbohydrates, lipids, proteins, nucleic acids), indicating both "good knowledge" and "poor knowledge" of the same concept in student population at pre-assessment.

Q10 and 11 target SLO 9 (Distinguish and compare the processes by which organisms fuel growth and cellular activities: cellular respiration and photosynthesis), indicating both "moderate knowledge" and "poor knowledge" of the same concept at pre-assessment

Q15 and 16 target SLO 13 (Diagram the flow of genetic information in cell), indicating both "moderate knowledge" and "very poor knowledge" of the same concept.

Therefore, if students appear to have a good background knowledge for one question that pertains to a given SLO, it doesn't guarantee that they will demonstrate the same level of competence when answering another question that targets the same SLO. A possible explanation of this observation is that most course SLOs encompass very complex and

multilayered biological concepts and, thus, knowing one part of it doesn't guarantee an understanding of another part.

Matching biological concepts	Question	PRE-TEST Correct answer (%) in declinining order	Groups
C14. Compare and contrast the outcomes of cell division via mitosis and meiosis	Q18	82.31%	Over 70% of students answered the questions correctly "good knowledge"
C5. Compare and contrast 4 classes of biological molecules (carbohydrates, lipids, proteins, nucleic acids)	Q5	75.77%	
C12. Explain how mistakes in cell division can lead to cancer and chromosomal abnormalities	Q13	68.85%	Over 50 to 70% of students answered the questions correctly "moderate knowledge"
C1. Recognize dependent, independent and controlled variables in an experiment	Q1	66.92%	
C6. Compare the structural hallmarks of bacterial (prokaryotic) cells and eukaryotic cells	Q7	66.54%	
C15. Recognize that DNA sequences have a meaning	Q19	61.92%	
C15. Recognize that DNA sequences have a meaning	Q20	56.92%	
C 9. Distinguish and compare the processes by which organisms fuel growth and cellular activities	Q11	56.54%	
C2. Summarize the basics of atomic structure	Q2	54.62%	
C4. Distinguish between three main types of chemical bonds: covalent, ionic and hydrogen	Q4	54.62%	
C13. Diagram the flow of genetic information in cell	Q16	53.08%	
C5. Compare and contrast 4 classes of biological molecules (carbohydrates, lipids, proteins, nucleic acids)	Q6	50.00%	30 to 50% of students answered the questions correctly "poor knowledge"
C 9. Distinguish and compare the processes by which organisms fuel growth and cellular activities	Q10	48.85%	
C14. Compare and contrast the outcomes of cell division via mitosis and meiosis	Q17	42.31%	
C8. Explain the principles of enzyme function	Q9	39.23%	
C3. Recognize and predict molecules or parts of molecules that are hydrophobic or hydrophilic	Q3	35.00%	
C7. Differentiate among different types of transport across plasma membrane	Q8	30.00%	
C14. Compare and contrast the outcomes of cell division via mitosis and meiosis	Q12	26.92%	Less than 30% of students answered the question correctly "very poor knowledge"
C13. Diagram the flow of genetic information in cell	Q15	23.46%	
C16. Explain what mutations are and how they affect genetic code	Q14	16.54%	

Figure 2. Assessment survey questions targeting the same biological concept can vary significantly in the level of background knowledge students have. Green connectors link questions targeting the same concept.

It has to be noted that both questions targeting SLO 15 (Recognize that DNA sequences have a meaning) are grouped next to each other in the "moderate knowledge" category. It also has to be noted that there's a certain amount of flexibility that the borders among different levels of knowledge categories have, thus potentially allowing for a closer grouping of some questions, e.g. one might argue that the difference between 48.85% (Q10) and 56.54% (Q11), both targeting SLO 9, is not that different, even though Q10 doesn't precisely meet the 50% minimum stated in the rubric for "moderate knowledge," and they can be grouped together.

Observation 2: **Students left the course with a significant learning gain and with different levels of understanding of key biological concepts ranging from poor to good (based on post-assessment)**

In post-assessments, student showed a higher number of correct answers to the same questions, and many questions moved to a higher knowledge category (Figure 3):

- Over 70% students answered Q 1, 3, 5, 6, 13, 18 and 19 correctly, so the student population, on the whole, demonstrated a **"good knowledge"** of the concepts targeted by these questions.
    - Q5 and 18 stayed in the "good knowledge" category from pre-assessment

- Q 1, 13, 19 moved up from “moderate knowledge” category demonstrating student learning
- Q 3 and 6 moved two categories up from “poor knowledge” category demonstrating significant student learning

- 50 to 70% of students answered Q 2, 4, 7, 9, 10, 11, 16, 17, and 20 correctly, so the student population, on the whole, demonstrated a **“moderate knowledge”** of the concepts targeted by these questions.
  - Q 2, 4, 7, 11, 16 and 20 stayed in this category from pre-assessment
  - Q 9, 10, 17 moved up from “poor knowledge” category demonstrating student learning
- Only 30 to 50% of students could answer Q8, 12, 14, 15 correctly, so the student population, on the whole, demonstrated a **“poor knowledge”** of the concepts targeted by these questions.
  - Q 8 stayed in this category from pre-assessment
  - Q 12, 14 and 15 moved up from “very poor knowledge” category, demonstrating some student learning

Question	PRE-TEST Correct answers (%) in declinining order	PRE-TEST Groups	POST-TEST Groups	Question	POST-TEST Correct answers (%) in declinining order
Q18	82.31%	“good knowledge”		Q5	83.23%
Q5	75.77%			Q6	83.23%
Q13	68.85%	“moderate knowledge”		Q18	81.94%
Q1	66.92%			Q13	81.29%
Q7	66.54%			Q3	74.84%
Q19	61.92%			Q1	72.90%
Q20	56.92%			Q19	70.97%
Q11	56.54%		“moderate knowledge”	Q2	68.39%
Q2	54.62%			Q7	65.81%
Q4	54.62%			Q4	63.23%
Q16	53.08%			Q10	61.29%
Q6	50.00%	“poor knowledge”		Q16	59.35%
Q10	48.85%			Q11	58.71%
Q17	42.31%			Q9	54.84%
Q9	39.23%			Q20	54.84%
Q3	35.00%			Q17	51.61%
Q8	30.00%			Q8	42.58%
Q12	26.92%	very poor knowledge	“poor knowledge”	Q15	38.71%
Q15	23.46%			Q14	32.90%
Q14	16.54%			Q12	31.79%

Figure 3. Student background knowledge of key biological concepts assessed in this project aligned with their knowledge in post-assessment.

Note that the category “very poor knowledge” (below 30% correct answers) disappeared in the post-assessment!

I also tracked how answers to questions targeting the same SLOs (SLOs 5, 9, 13, 14, 15) shifted in the post-test, and it turns out that taking the course appeared to improve understanding of some of the concepts:

- Q5 and 6 (target SLO 5) merged together in “good knowledge” category

- Q 10 and 11 (target SLO 9) merged together in the “moderate knowledge” category (Figure 4).
- Q 18, Q17, Q12 (target SLO 14) were still spread over three different categories: “good knowledge,” “moderate knowledge” and “poor knowledge”
- Q15 and 16 (target SLO 13) were spread over “good knowledge” and ”poor knowledge” categories
- Q 19 and 20 (target SLO 15) split from one category (“moderate knowledge”) into two: “moderate knowledge” and “poor knowledge”

Thus again, knowing/ learning one aspect of the same concept doesn’t guarantee knowing/ learning another one.

Question	POST-TEST Correct answers (%) in declinining order	Matching biological concepts
Q5	83.23%	C5. Compare and contrast 4 classes of biological molecules (carbohydrates, lipids, proteins, nucleic acids)
Q6	83.23%	C5. Compare and contrast 4 classes of biological molecules (carbohydrates, lipids, proteins, nucleic acids)
Q18	81.94%	C14. Compare and contrast the outcomes of cell division via mitosis and meiosis
Q13	81.29%	C13. Diagram the flow of genetic information in cell
Q3	74.84%	C3. Recognize and predict molecules or parts of molecules that are hydrophobic or hydrophilic
Q1	72.90%	C1. Recognize dependent, independent and controlled variables in an experiment
Q19	70.97%	C15. Recognize that DNA sequences have a meaning
Q2	68.39%	C2. Summarize the basics of atomic structure
Q7	65.81%	C6. Compare the structural hallmarks of bacterial (prokaryotic) cells and eukaryotic cells
Q4	63.23%	C4. Distinguish between three main types of chemical bonds: covalent, ionic and hydrogen
Q10	61.29%	C 9. Distinguish and compare the processes by which organisms fuel growth and cellular activities
Q16	59.35%	C13. Diagram the flow of genetic information in cell
Q11	58.71%	C 9. Distinguish and compare the processes by which organisms fuel growth and cellular activities
Q9	54.84%	C8. Explain the principles of enzyme function
Q20	54.84%	C15. Recognize that DNA sequences have a meaning
Q17	51.61%	C14. Compare and contrast the outcomes of cell division via mitosis and meiosis
Q8	42.58%	C7. Differentiate among different types of transport across plasma membrane
Q15	38.71%	C13. Diagram the flow of genetic information in cell
Q14	32.90%	C16. Explain what mutations are and how they affect genetic code
Q12	31.79%	C14. Compare and contrast the outcomes of cell division via mitosis and meiosis

Figure 4. Assessment survey questions targeting the same biological concept can vary significantly in the level of knowledge students had or gained in the course. Green connectors link questions targeting the same concept.

Observation 3: **As students progressed through the course, their improvement in mastery of different concepts varied from nonexistent to significant (depending on the concept)**

In post-assessment, student improvement in concept mastery varied significantly from question to question, and I grouped them in categories for ease of referencing, as shown in Figure 5.

Student population improvement was irrespective of the background level of knowledge; however, in many cases, stronger improvement can be noticed for questions that were more difficult for students to answer correctly in the pre-test (Figure 6).

Question	Difference between post-test and pre-test	Groups
Q3	39.84%	Good improvement
Q6	33.23%	
Q14	16.36%	Moderate improvement
Q9	15.61%	
Q15	15.25%	
Q2	13.77%	
Q8	12.58%	
Q10	12.44%	
Q13	12.44%	
Q17	9.30%	Slight improvement
Q19	9.05%	
Q4	8.61%	
Q5	7.46%	
Q16	6.27%	
Q1	5.98%	
Q12	4.87%	No improvement
Q11	2.17%	
Q18	-0.37%	
Q7	-0.73%	
Q20	-2.08%	

Figure 5. Student learning of key biological concepts can be classified in four categories: "good improvement," "moderate improvement," "slight improvement," and "no improvement" (based on student answers to post-assessment)

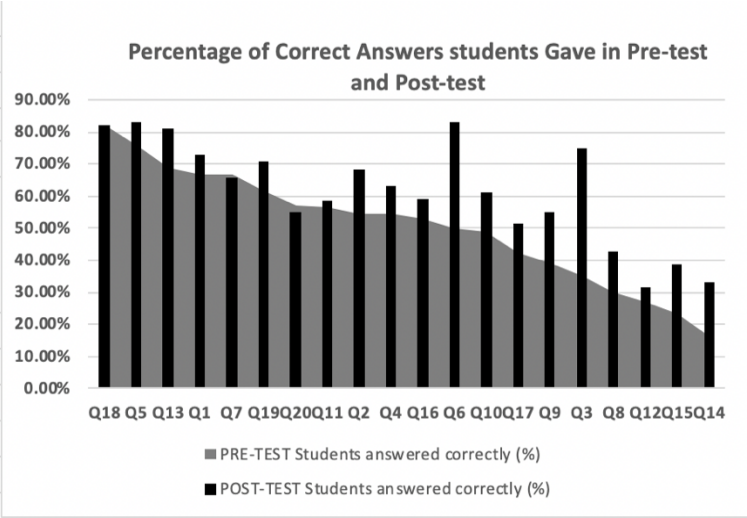
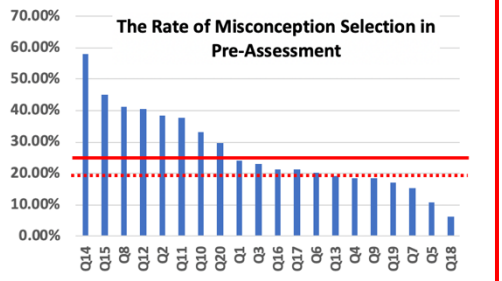


Figure 6. Comparison between the number of correct answers in pre- and post-assessment.

Observation 4: Students have misconceptions about certain biological concepts, which can prevent them from learning those concepts

The multiple-choice assessment tool used in this project was designed by the HWC Biology department Assessment Committee (BioAC) in such a way that the incorrect answer choices reflected common student misconceptions about the topic. Since most questions had four answer choices, we decided to consider the incorrect answer choices that were picked by students at a rate higher than 25% to be "misconceptions." In some cases, we considered incorrect answer choices picked at a rate between 19 and 25% to be potential misconceptions as well, considering that a few questions had five answer choices. Figure 7 shows survey questions aligned in order from the misconception rate in the post-assessment to the lowest; the cut-offs for misconceptions and potential misconceptions are shown in two different forms, as a table and graphs, indicating which questions belong to which groups.

Question	Misconceptions (%) Pretest	Question	Misconceptions (%) Posttest
Q14	58.08%	Q14	49.68%
Q15	45.00%	Q15	37.42%
Q8	41.15%	Q8	35.48%
Q12	40.38%	Q11	32.26%
Q2	38.46%	Q12	30.46%
Q11	37.69%	Q20	29.03%
Q10	33.08%	Q4	22.58%
Q20	29.62%	Q2	21.94%
Q1	24.23%	Q10	21.94%
Q3	23.08%	Q1	17.42%
Q16	21.15%	Q17	16.77%
Q17	21.15%	Q7	16.13%
Q6	20.38%	Q19	14.84%
Q13	19.23%	Q9	14.19%
Q4	18.46%	Q16	14.19%
Q9	18.46%	Q3	9.68%
Q19	16.92%	Q13	9.68%
Q7	15.38%	Q6	8.39%
Q5	10.77%	Q18	7.10%
Q18	6.15%	Q5	6.45%



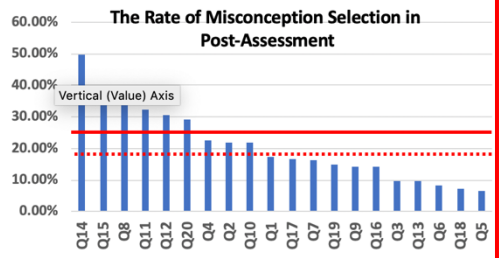
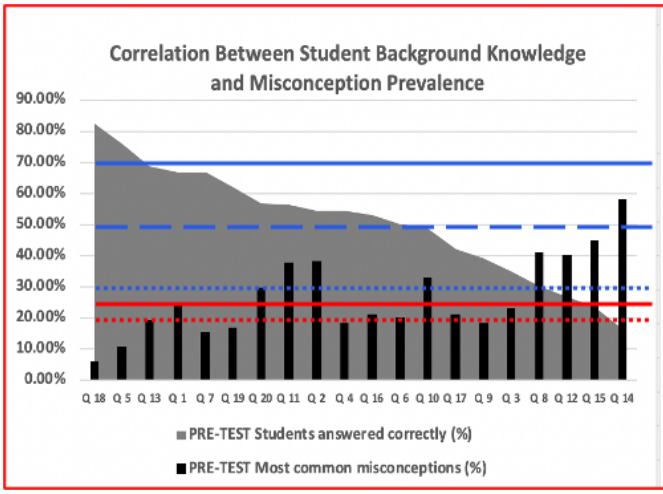


Figure 7. Incorrect answers in pre- and post-assessment.

Solid red line represents a cut-off for misconceptions that were selected at a rate higher than 25%

Dotted red line represents a cut-off for potential misconceptions selected at a rate 19-25%



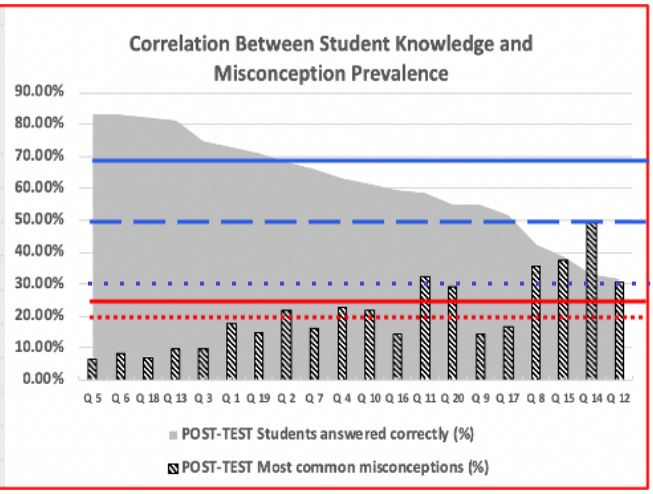


Figure 8. Correlation between student correct answers and misconception selection in the pre- and post-assessment.

Solid blue line marks the cut off for “good knowledge” category (70% or more correct answers)

Dashed blue line marks the cut off for “moderate knowledge” category (50-70% correct answers),

Dotted blue line divides the “poor knowledge” (30-50% or more correct answers) and “very poor knowledge” (below 30% of correct answers) categories, as shown in Figure 3

Solid red line represents a cut-off for misconceptions that were selected at a rate higher than 25%

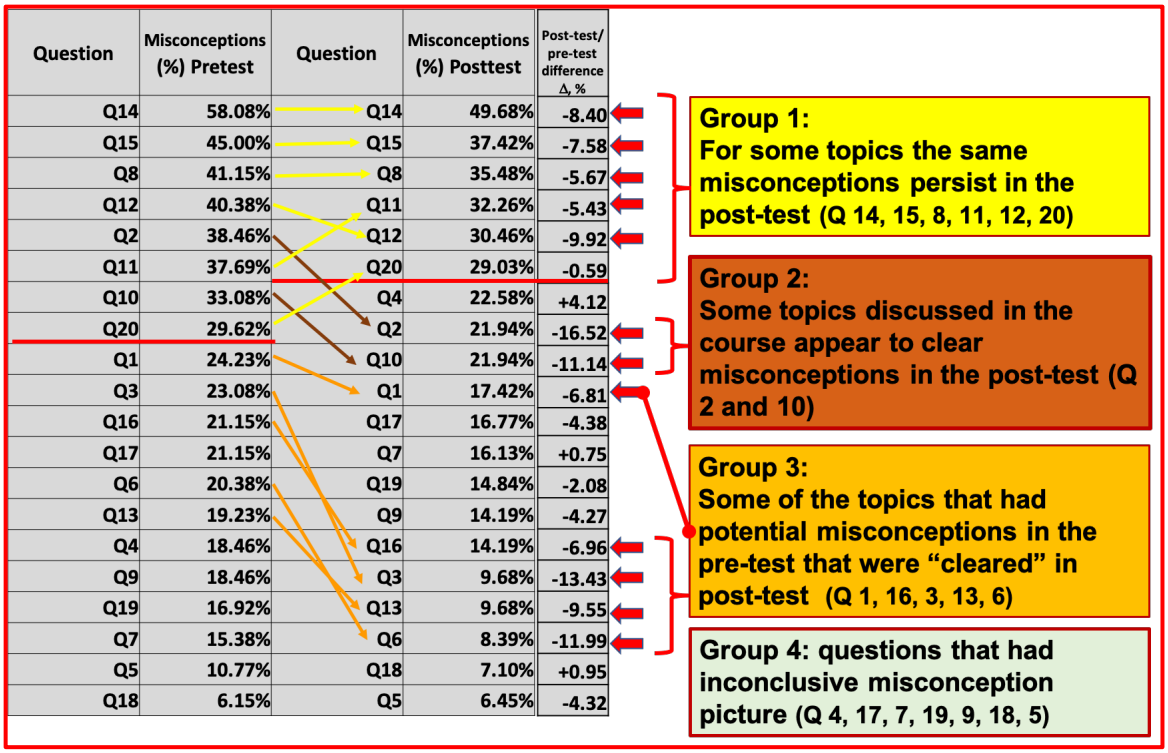
Dotted red line represents a cut-off for potential misconceptions selected at a rate 19-25%, as shown in Figure 7.

Student misconceptions were not apparent for questions where student background knowledge was good (pre-assessment: Q18 and 5; Figure 8: left graph), but the strongest misconceptions were found for questions where student background knowledge was poor or very poor (pre-assessment: Q10, 17, 9, 3, 8, 12, 15, 14; Figure 8: left graph).

Observation 5: Taking the course allowed students to clear some (but not all) of the biological misconceptions

The proportion of student correct answers increased significantly in the post-assessment (Figure 8: right graph), and with a noticeable number of misconceptions and potential misconceptions clearing, pronounced misconceptions persisted in the "poor knowledge" category mostly.

To better understand which misconceptions are "cleared" during the course, I decided to



focus on those that students selected at least 5% less frequently in the post-assessment compared to pre-assessment, they are marked with thick red arrows in Figure 9.

Figure 9. Assessment questions ordered based on the misconception selection in the post-test (post-assessment).

Thin yellow, brown and orange arrows show the change in question position in pre- and post-assessment

Thick red arrows mark questions where students selected misconceptions at least 5% less frequently in the post-assessment compared to pre-assessment

Yellow, brown, orange and light green boxes specify four question groups based on the frequency of misconception (or potential misconception) selection in the post-assessment and reduction of misconception selection in the post-assessment (compared to pre-assessment) – see text for details.

I have grouped assessment questions based on the frequency of misconception (or potential misconception) selection in the post-assessment and reduction of misconception selection in the post-assessment (compared to pre-assessment) – see Figure 9:

Group 1 of assessment questions (includes Q 14, 15, 8, 11, 12, 20) shows misconception selection rate in the pre-test at 29% or higher and a reduction in misconception selection in the post-test by 5-10% (except for Q20). All of these questions, however, still retained a misconception selection rate of 29% or higher in the post-assessment, indicating that these topics were most difficult for students, and while the course mostly improved student learning of these concepts, misconceptions among the student population assessed were not fully resolved by the conclusion of the course.

Group 2 of assessment questions (includes Q 2 and 10) shows misconception selection rate in the pre-test at 29% or higher and a reduction in misconception selection in the post-test by more than 10%. Moreover, this decrease in misconception selection brings it down to less than 25%, potentially indicating that the misconceptions for these two questions were "cleared" by taking the course.

Group 3 of assessment questions (includes Q 1, 16, 3, 13 and 6) shows misconception selection rate in the pre-test at 19 to 24% (potential misconceptions) and a reduction in misconception selection in the post-test by more than 5%, which brings the misconception rate selection for these questions further down, possibly clearing potential misconceptions. This group is tentative as incorrect answer selection clustering can be random.

Group 4 of assessment questions (includes Q 4, 17, 7, 19, 9, 18 and 5) do not conclusively show any noticeable incorrect answer preference in pre- or post-assessment, thus indicating that either these topics do not have common misconceptions, or they were not predicted in the assessment question design.

Finally, I have combined all the above-described categories, classifications and groups and applied them to analysis of student performance on each question of the assessment survey. The primary classification, upon which the questions are grouped, is the Group 1, 2, 3 and 4 classification based on misconception clearance; the rest of the groupings are indicated under the table of each question, as well as color-coded to match the colors/ terms used for each classification (see Appendix). Most importantly, I've highlighted which questions and misconceptions require particular attention in issuing recommendations. This way, faculty can be more strategic in working to eliminate these interfering misconceptions as one way to help improve student learning. Preliminary recommendations have been offered [1], and these detailed analyses map out the route for detailed recommendations that the HWC Biology Department will work on in the foreseeable future.

References:

1. Bijelic, J. (2019). Biology Department Unit Level Assessment Liaison Report. Retrieved on May 12, 2020 from http://www.ccc.edu/colleges/washington/departments/Documents/hwcac/unit/2018-2019/hwcac-unit-2018-2019-biology-report-bijelic.pdf
2. Cohen, J. Statistical power analysis for the behavioral sciences. Routledge, 2013.

APPENDIX

Group 1:
For some topics the same misconceptions persisted in the post-test (Q 14, 15, 8, 11, 12, 20)

Q 14. A young man develops skin cancer that does not spread to any other tissues; the mutation responsible for the cancer arose in a single skin cell. If he and his wife (who does not have skin cancer) subsequently have children, which of the following statements is CORRECT?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. All the man's children will inherit the mutation responsible for skin cancer.			
B. All the man's children will inherit the mutation responsible for skin cancer if the mutation is dominant.			
C. Some of the man's children may inherit the mutation responsible for skin cancer depending on which of his chromosomes they inherit. (Common Misconception)	58.08	49.69	-8.40
D. None of the man's children will inherit the mutation responsible for skin cancer. (Correct Answer)	16.54 very poor	32.90 poor	16.36 moderate improvement

- Very poor background knowledge of the concept, then moderate improvement in the post-test, but still insufficient for a good concept mastery
- **Misconception C** presents a significant interference in learning - **recommendations are needed**

1

Group 1:
For some topics the same misconceptions persisted in the post-test (Q 14, 15, 8, 11, 12, 20)

Q 15. What does the genetic information usually provide instructions for?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Assembling amino acids into protein molecules (Correct Answer)	23.46 very poor	38.71 poor	15.25 moderate improvement
B. Assembling protein molecules into amino acids			
C. Assembling nucleotides into proteins			
D. Assembling amino acids into RNA (Common Misconception)	45.00	37.42	-7.58

- Very poor background knowledge of the concept, followed by moderate improvement in the post-test but still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- **Misconception D** presents an interference in learning

2

Group 1:
For some topics the same misconceptions persisted in the post-test (Q 14, 15, 8, 11, 12, 20)

Q 8. Which of the following substances will diffuse through a phospholipid bilayer membrane that contains NO proteins?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. ions			
B. glucose (Common Misconception)	41.15	35.48	-5.68
C. vitamins			
D. oxygen gas (Correct Answer)	30.00 poor	42.58 poor	12.58 moderate improvement.

- Poor background knowledge of the concept, followed by moderate improvement in the post-test but still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- **Misconception B** presents an interference in learning

3

Group 1:
For some topics the same misconceptions persisted in the post-test (Q 14, 15, 8, 11, 12, 20)

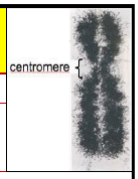
Q 11. Which of the following statements is the most accurate?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Plants carry out cellular respiration and photosynthesis. (Correct Answer)	56.54 moderate	58.71 moderate	2.17 no improvement
B. Plants carry out only photosynthesis. (Common Misconception)	37.69	32.26	-5.43
C. Animals carry out cellular respiration and photosynthesis.			
D. Animals carry out only photosynthesis.			

- Poor background knowledge of the concept, followed by moderate improvement in the post-test but still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- **Misconception B** presents an interference in learning

4

Group 1:
For some topics the same misconceptions persisted in the post-test (Q 14, 15, 8, 11, 12, 20)



Q 12. The following photograph shows a single replicated chromosome (consisting of two sister chromatids) just before mitosis. This chromosome contains:

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. two single-stranded DNA molecules.			
B. one double-stranded DNA molecule. (Common Misconception)	40.38	30.46	-9.92
C. two double-stranded DNA molecules. (Correct Answer)	26.92 very poor	31.79 poor	4.87 no improvement
D. one single-stranded DNA molecules.			

- Very poor background knowledge of the concept and no improvement in the post-test
- **Recommendations are needed to improve student learning of this concept**
- **Misconception B** presents an interference in learning

5

Group 1:
For some topics the same misconceptions persisted in the post-test (Q 14, 15, 8, 11, 12, 20)

Q 20. Which of the following could be affected by the information in the DNA molecules of an organism?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Both an organism's physical characteristics and its behavior. (Correct Answer)	56.92 moderate	54.84 moderate	-2.08 no improvement
B. An organism's physical characteristics but not its behavior. (Common Misconception)	29.62	29.03	-0.59
C. An organism's behavior but not its physical characteristics.			
D. Neither an organism's physical characteristics nor its behavior.			

- Moderate background knowledge of the concept and no improvement in the post-test
- **Recommendations are needed to improve student learning of this concept**
- **Misconception B** may present an interference in learning
- Note: Is this something we discuss in Bio 121?

6

Group 2:
Some topics discussed in the course appear to clear misconceptions in the post-test (Q 2 and 10)

Q 2. What do molecules of water consist of?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Atoms of oxygen and nitrogen.			
B. Molecules of oxygen and hydrogen. (Common Misconception)	**38.46**	**21.94**	**-16.52**
C. Atoms of oxygen and hydrogen. (Correct Answer)	**54.62** moderate	**68.39** moderate	**13.77** moderate improvement
D. Molecules of oxygen and nitrogen.			

- Moderate background knowledge of the concept followed by moderate improvement in the post-test, but still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- **Misconception B** was significant in the pre-test but appears to be **cleared in the post-test (?)**

7

Group 2:
Some topics discussed in the course appear to clear misconceptions in the post-test (Q 2 and 10)

Q 10. You eat a grape high in glucose content. How could a glucose molecule from the grape provide energy to fuel your body?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Glucose is digested into simpler molecules, leading to breakdown of ATP. (Common Misconception)	**33.08**	**21.94**	**-11.94**
B. The chemical energy of glucose is completely converted to heat.			
C. The chemical energy of glucose is used to produce ATP. (Correct Answer)	**48.85** poor	**61.29** moderate	**12.44** moderate improvement
D. The chemical energy of glucose is used to breakdown ATP.			

- Poor background knowledge of the concept followed by moderate improvement in the post-test, but still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- **Misconception A** was significant in the pre-test but appears to be **cleared in the post-test (?)**
  - Note that reduction in selection of the misconception approximately matches the increase in correct answers

8

Group 3:

Some of the topics showed a significant reduction of misconceptions in post-test even though the initial percentage of misconceptions slightly lower than 25% still (Q 1, 16, 3, 13, 6)

Q 1. A farmer thinks that type of soil and amount of water affect the growth of his carrot plants, and he wants to find out if he is right. The farmer first tests if the type of soil affects the growth of the carrot plants. He uses three different types of soil, and he places 10 carrot plants in each type of soil. He uses the same amount of water for all the plants. Why is it important to use the same amount of water for all the plants?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. By using the same amount of water, the farmer can learn about both the effect of the amount of water and the effect of the type of soil. (Common Misconception)	24.23	17.42	-6.81
B. By using the same amount of water, the farmer can learn about the effect of the amount of water.			
C. If he does not use the same amount of water, the farmer cannot learn about the effect of the type of soil. (Correct Answer)	66.92 moderate	72.90 good	5.98 slight imp.
D. It is NOT important to use the same amount of water because the farmer is not testing the effect of the amount of water.			

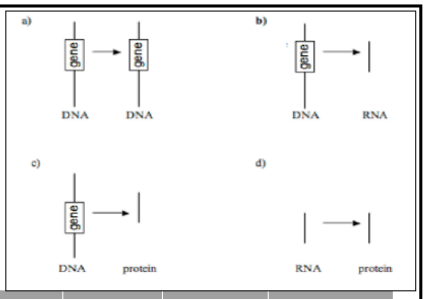
- Moderate background knowledge of the concept followed by a slight improvement achieved a good understanding level of the concept by student population
- Recommendations can still be made to improve student understanding of the concept
- Misconception A may have presented an interference in pre-test but was cleared in the post-test

9

Group 3:

Some of the topics showed a significant reduction of misconceptions in post-test even though the initial percentage of misconceptions slightly lower than 25% still (Q 1, 16, 3, 13, 6)

Q 16. Transcription is represented best by which of the following diagrams?



Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. DNA to DNA (Common Misconception)	21.15	14.19	-6.96
B. DNA to RNA (Correct Answer)	53.08 moderate	59.35 moderate	6.27 slight imp.
C. DNA to protein			
D. RNA to protein			

- Moderate background knowledge of the concept followed by a slight improvement was still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- Misconception A may have presented an interference in pre-test but was cleared in the post-test

10

Group 3:
Some of the topics showed a significant reduction of misconceptions in post-test even though the initial percentage of misconceptions slightly lower than 25% still (Q 1, 16, 3, 13, 6)

Q 3. Which of the following statements about lipids is correct?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. They are hydrophobic and water insoluble. (Correct Answer)	35.00 poor	74.84 good	39.84 good improvement
B. They are hydrophobic and water soluble. (Common Misconception)	23.08	9.68	-13.43
C. They are hydrophilic and water insoluble.			
D. They are hydrophilic and water soluble.			

- Poor background knowledge of the concept followed by a good improvement achieved a good understanding level of the concept by student population
- Recommendations can still be made to improve student understanding of the concept
- Misconception B may have presented an interference in pre-test but was cleared in the post-test

11

Group 3:
Some of the topics showed a significant reduction of misconceptions in post-test even though the initial percentage of misconceptions slightly lower than 25% still (Q 1, 16, 3, 13, 6)

Q 13. Which of the following is TRUE concerning cancer cells?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. They are produced as a result of genetic mutation. (Correct Answer)	68.85 moderate	81.29 good	12.44 modest imp.
B. They never leave the site where they are formed.			
C. They undergo the normal cell cycle control. . (Common Misconception)	19.23	9.68	-9.55
D. They stop dividing when they reach certain size.			

- Moderate background knowledge of the concept followed by a modest improvement achieved a good understanding level of the concept by student population
- Recommendations can still be made to improve student understanding of the concept
- Misconception C may have presented an interference in pre-test but was cleared in the post-test

12

Group 3:
Some of the topics showed a significant reduction of misconceptions in post-test even though the initial percentage of misconceptions slightly lower than 25% still (Q 1, 16, 3, 13, 6)

Q 6. What are the three categories of organic compounds that provide energy for living systems?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. carbohydrates, lipids and proteins (Correct Answer)	50.00 poor	83.23 good	33.23 good improvement
B. lipids, proteins and enzymes			
C. carbohydrates, vitamins, proteins (Common Misconception in pre-test)	20.38		
D. proteins, nucleic acids, carbohydrates (Common Misconception in post-test)		8.39	

- Poor background knowledge of the concept followed by a good improvement achieved a good understanding level of the concept by student population
- Recommendations can still be made to improve student understanding of the concept
- Misconception C may have presented an interference in pre-test but was cleared in the post-test

13

Group 4:
Questions that have inconclusive misconception picture (Q 4, 17, 7, 19, 9, 18, 5)

Q 4. Which of the following is responsible for the bonding of water molecules to each other?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Nonpolar covalent bond (Common Misconception)	18.46	22.58	+ 4.12
B. Polar covalent bond			
C. Ionic bond			
D. Hydrogen bond (Correct Answer)	54.62 moderate	63.23 moderate	8.61 slight improvement
E. Peptide bond			

- Moderate background knowledge of the concept followed by a slight improvement was still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- Misconception A may have presented an interference in pre-test and persisted in the post-test

14

Group 4:
Questions that have inconclusive misconception picture (Q 4, 17, 7, 19, 9, 18, 5)

Q 17. Which of the following statements regarding the differences between mitosis and meiosis is CORRECT?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Mitosis produces 4 haploid cells, meiosis produces 2 haploid cells.			
B. Mitosis produces 2 haploid cells, meiosis produces 4 haploid cells.			
C. Mitosis produces 2 diploid cells, meiosis produces 4 haploid cells. (Correct Answer)	42.31 poor	51.61 moderate	9.30 slight improvement
D. Mitosis produces 4 haploid cells, meiosis produces 2 diploid cells. (Common Misconception)	21.15	16.77	-4.38

- Poor background knowledge of the concept followed by a slight improvement was still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- Misconception D may have presented an interference in pre-test and persisted at a similar level in the post-test

15

Group 4:
Questions that have inconclusive misconception picture (Q 4, 17, 7, 19, 9, 18, 5)

Q 7. What is TRUE about the inside of an animal cell?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. The inside of an animal cell contains structures that carry out specialized functions for the cell, but no water or air. The inside of the cell is completely solid.			
B. The inside of an animal cell contains water and molecules dissolved in the water, but no structures that perform specialized functions for the cell.			
C. The inside of an animal cell contains air and structures that perform specialized functions for the cell, but no water. (Common Misconception)	15.38	16.13	+ 0.75
D. The inside of an animal cell contains water, molecules dissolved in the water, and structures that perform specialized functions for the cell. (Correct Answer)	66.54 moderate	65.81 moderate	-0.73 no improvement

- Moderate knowledge of the concept followed and no improvement in the post-test
- **Recommendations are needed to improve student learning of this concept**
- No prominent misconceptions detected

16

Group 4:
Questions that have inconclusive misconception picture (Q 4, 17, 7, 19, 9, 18, 5)

Q 19. Which of the following have DNA molecules?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Only humans. (Common Misconception in post-test)		14.84	n/a
B. Humans, dogs, salt crystals.			
C. Humans, dogs, trees. (Correct Answer)	61.92 moderate	70.97 good	9.05 slight improvement
D. Humans, pure water, bacteria. (Common Misconception in pre-test)	16.92		n/a

- Moderate background knowledge of the concept followed by a slight improvement achieved a good understanding level of the concept by student population
- Recommendations can still be made to improve student understanding of the concept
- Misconception D may have presented an interference in pre-test but cleared in the post-test

17

Group 4:
Questions that have inconclusive misconception picture (Q 4, 17, 7, 19, 9, 18, 5)

Q 9. Which of the following statements regarding enzyme function is FALSE?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. Enzymes may be used many times for the same specific reaction. (One of two common misconceptions in pre-test)	18.46	-	
B. Enzymes are highly specific for the molecules to which they attach.			
C. An enzyme's function depends on its three-dimensional shape. (One of two common misconceptions in pre-test, remained in post-test)	18.46	14.19	-4.27
D. An enzyme's function is unaffected by changes in pH. (Correct Answer)	39.23 poor	54.84 moderate	15.61 moderate improvement
E. Enzymes are proteins that function as biological catalysts.			

- Poor background knowledge of the concept followed by moderate improvement improvement in the post-test was still insufficient for a good concept mastery
- **Recommendations are needed to improve student learning of this concept**
- Misconceptions A and C may have presented an interference in pre-test, misconception A cleared in the post-test

18

Group 4:
Questions that have inconclusive misconception picture (Q 4, 17, 7, 19, 9, 18, 5)

Q 18. How similar is your genetic information to that of your parents?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. You inherit 75% of the alleles from your dad.			
B. You inherit 75% of the alleles from your mom.			
C. You inherit 50% of the alleles from one parent and 50% of the alleles from the other parent. **(Correct Answer)**	**82.31 good**	**81.94 good**	**-0.37** No improvement
D. You inherit 100% of the alleles from either parent.			

- Good background level of knowledge of the concept that stayed the same in the post-test
- Recommendations still can be issued to further improve student comprehension of this concept
- No prominent misconceptions

19

Group 4:
Questions that have inconclusive misconception picture (Q 4, 17, 7, 19, 9, 18, 5)

Q 5. What are the building blocks that make up protein molecules?

Answer choices	Pre-test %	Post-test %	Post-/ Pre-test Δ
A. nucleotides			
B. amino acids **(Correct Answer)**	**75.77 good**	**83.23 good**	**7.46** slight improvement
C. monosaccharides			
D. fatty acids			

- Good background level of knowledge of the concept that was slightly improved in the post-test
- Recommendations still can be issued to further improve student comprehension of this concept
- No prominent misconceptions

20